## Claims

What is claimed is:

1. A display device, comprising a display screen, wherein the display screen further comprises:

a fluorescent layer that is operable to absorb excitation light to emit visible light, and

a first layer on a first side of the fluorescent layer operable to transmit the excitation light and to reflect the visible light.

2. The device as in claim 1, wherein the fluorescent layer comprises a phosphor material.

3. The device as in claim 2, wherein the phosphor material comprises nanoscale phosphor grains.

4. The device as in claim 2, wherein the phosphor material absorbs excitation light at an ultra violet wavelength.

5. The device as in claim 2, wherein the phosphor material absorbs excitation light at a violet wavelength.

6. The device as in claim 2, wherein the phosphor material absorbs excitation light at a wavelength less than 420 nm.

7. The device as in claim 2, wherein the fluorescent layer comprises a non-phosphor fluorescent material.

8. The device as in claim 7, wherein the fluorescent material comprises quantum dots.

9. The device as in claim 7, wherein the non-phosphor fluorescent material absorbs excitation light at an ultra violet wavelength.

10. The device as in claim 7, wherein the non-phosphor fluorescent material absorbs excitation light at a violet wavelength.

11. The device as in claim 7, wherein the non-phosphor fluorescent material absorbs excitation light at a wavelength less than 420 nm.

12. The device as in claim 1, wherein the fluorescent layer comprises a plurality of different of fluorescent materials which absorb the excitation light to emit light at different visible wavelengths.

13. The device as in claim 12, wherein the fluorescent layer is patterned into parallel stripes, and wherein at least two adjacent stripes have at least two different fluorescent materials that emit light at two different visible wavelengths, respectively.

14. The device as in claim 1, further comprising a Fresnel lens formed on the first side of the fluorescent layer to direct the excitation light incident to the screen at different angles to be approximately normal to the fluorescent layer.

15. The device as in claim 14, wherein the Fresnel lens is in a telecentric configuration for the incident excitation light.

16. The device as in claim 1, wherein the first layer includes a stack of dielectric layers of at least two different dielectric materials.

17. The device as in claim 1, wherein the first layer is an multi-layer interference filter.

18. The device as in claim 1, wherein the first layer comprises:

a lens having a first surface to receive the excitation light and a second opposing surface facing the fluorescent layer and coated with a reflective layer to reflect the excitation light and the visible light,

wherein the reflective layer comprises an aperture in a center of the second surface to allow for the excitation light to transmit through.

19. The device as in claim 18, wherein the lens is configured to focus the excitation light at the aperture.

20. The device as in claim 18, wherein the reflective layer is a metallic reflective layer.

21. The device as in claim 1, wherein the fluorescent layer comprises a plurality of parallel phosphor stripes, wherein at least three adjacent phosphor stripes are made of three different phosphors: a first phosphor to absorb the excitation light to emit light of a first color, a second phosphor to absorb the excitation light to emit light of a second color, and a third phosphor to absorb the excitation light to emit light of a third color.

22. The device as in claim 21, wherein the phosphors absorb excitation light at an ultraviolet wavelength.

23. The device as in claim 21, wherein the phosphors absorb excitation light at a violet wavelength.

24. The device as in claim 21, wherein the phosphors absorb excitation light at a wavelength less than 420 nm.

25. The device as in claim 1, wherein the fluorescent layer is patterned into parallel stripes and two adjacent stripes have two different fluorescent materials that emit light at two different visible wavelengths, respectively, and

wherein the screen further comprises a lens layer on the first side of the fluorescent layer, the lens layer comprising a plurality of cylindrical lenses having cylindrical axes parallel to the stripes and being positioned to correspond to the stripes, respectively.

26. The device as in claim 1, wherein the fluorescent layer comprises a plurality of parallel phosphor stripes, wherein at least three adjacent phosphor stripes are made of three different phosphors: a first phosphor to absorb the excitation light to emit light of a first color, a second phosphor to absorb the excitation light to emit light of a second color, and a third phosphor to absorb the excitation light to emit light of a third color,

wherein the first layer comprises:

a lens layer on the first side of the fluorescent layer, the lens layer comprising a plurality of cylindrical lenses having cylindrical axes parallel to the phosphor stripes and being positions to correspond the phosphor stripes, respectively, and

a reflective layer coated on a lens surface of each cylindrical lens that faces the fluorescent layer and configured to have a slit aperture along the cylindrical axis

of the cylindrical lens to transmit the excitation light while the excitation light entering at other positions of the cylindrical lens is blocked by the reflective layer.

27. The device as in claim 26, wherein each cylindrical lens is configured to focus the excitation light to the slit aperture.

28. The device as in claim 26, wherein the display screen further comprises an index-matching material between the lens layer and the fluorescent layer.

29. The device as in claim 26, further comprising:

a first optical absorbent material mixed in the first phosphor that absorbs light of the second and third colors and transmits light of the first color;

a second optical absorbent material mixed in the second phosphor that absorbs light of the first and third colors and transmits light of the second color; and

a third optical absorbent material mixed in the third phosphor that absorbs light of the first and second colors and transmits light of the third color.

30. The device as in claim 1, wherein the screen further comprises a second layer on a second side of the fluorescent layer to transmit the visible light and to block the excitation light, and

wherein at least one of the first and second layers comprises a plurality of dielectric layers forming a wavelength-selective optical filter.

31. The device as in claim 30, wherein the dielectric layers comprise alternating high and low index dielectric layers.

32. The device as in claim 30, wherein the dielectric layers are polymeric materials.

33. The device as in claim 30, wherein the dielectric layers are polyester materials.

34. The device as in claim 1, wherein the fluorescent layer is patterned to have different fluorescent regions with different fluorescence materials.

35. The device as claim 34, wherein the fluorescent layer is patterned to further comprise non-fluorescent regions without a fluorescent material to directly display light of the optical excitation beam.

36. The device as in claim 34, wherein the screen further comprises:

a second layer on a second side of the fluorescent layer to transmit the visible light and to block the excitation light; and

a contrast enhancing layer formed over the second layer to comprise a plurality different filtering regions that spatially match the fluorescent regions, wherein each filtering region transmits light of a color that is emitted by a corresponding matching fluorescent region and blocks light of other colors.

37. The device as in claim 34, wherein each fluorescent region includes a boundary that is optically reflective.

38. The device as in claim 34, wherein each fluorescent region includes a boundary that is optically absorbent.

39. The device as in claim 1, wherein the fluorescent layer comprises a plurality of parallel fluorescent stripes, wherein at least three adjacent fluorescent stripes are made of three different fluorescent materials: a first fluorescent material to absorb the excitation light to emit light of a first color, a second fluorescent material to absorb the excitation light to emit light of a second color, and a third fluorescent material to absorb the excitation light to emit light of a third color,

the device further comprising:

an optical module operable to produce a scanning beam of the excitation light that scans along a direction perpendicular to the parallel fluorescent stripes, the scanning beam carrying optical pulses that carry information on an image to be displayed;

an optical sensing unit positioned to receive a portion of light from the screen and operable to produce a monitor signal indicating a spatial alignment of the scanning beam with respect to different fluorescent stripes on the screen; and

a feedback control mechanism operable to receive the monitor signal and to control the optical module so as to adjust a timing of the optical pulses carried by the scanning beam in response to the monitor signal to correct a spatial alignment error of the scanning beam on the screen indicated by the monitor signal.

40. The device as in claim 1, wherein the fluorescent layer comprises a plurality of parallel fluorescent stripes, wherein at least three adjacent fluorescent stripes are made of three different fluorescent materials: a first fluorescent material to absorb the excitation light to emit light of a first color, a second fluorescent material to absorb the excitation light to emit light of a second color, and a third

fluorescent material to absorb the excitation light to emit light of a third color, and

wherein the fluorescent layer further comprises

a first optical absorbent material mixed in the first fluorescent material that absorbs light of the second and third colors and transmits light of the first color;

a second optical absorbent material mixed in the second fluorescent material that absorbs light of the first and third colors and transmits light of the second color; and

a third optical absorbent material mixed in the third fluorescent material that absorbs light of the first and second colors and transmits light of the third color.

41. The device as in claim 1, wherein the fluorescent layer comprises a plurality of parallel fluorescent stripes, each fluorescent stripe to absorb the excitation light to emit light of a designated color,

the device further comprising:

a contrast enhancing layer positioned relative to the fluorescent layer so that the fluorescent layer is placed at a position between the contrast enhancing layer and the first layer,

wherein the contrast enhancing layer comprises a plurality of different filtering stripes that spatially match the fluorescent stripes, where each filtering stripe transmits light of a color that is emitted by a corresponding matching fluorescent stripe and blocks light of other colors.

42. The device as in claim 1, further comprising:

a laser module operable to project and scan a laser beam as the excitation light onto the screen, the laser beam carrying optical pulses that carry information on an image to be displayed,

wherein the laser module comprises a modulation control which combines a pulse code modulation and a pulse width modulation to modulate the laser beam to produce image grey scales.

43. The device as in claim 1, further comprising:

a laser module operable to simultaneously project and scan a plurality of laser beams as the excitation light onto different portions of the screen, each laser beam carrying optical pulses that carry information on a portion of an image to be displayed at a respective portion of the screen.

44. The device as in claim 1, further comprising a laser module which comprises:

a diode laser operable to produce a laser beam as the excitation light onto the screen, the laser beam carrying optical pulses that carry information on an image to be displayed;

a scanning module to scan the laser onto the screen to display the image;

a mechanism to monitor image data bits to be modulated on the laser beam to produce a black pixel monitor signal; and

a laser control coupled to receive the black pixel monitor signal and operable to operate the diode laser at a driving current below a laser threshold current without turning off the driving current to produce a virtue black color on the screen when the black pixel monitor signal indicates a length of black pixels is less than a threshold and turn off the driving current to produce a true black color on the screen when the black pixel monitor signal indicates a length of black pixels is greater than a threshold.

45. The device as in claim 1, further comprising:

a laser to produce a laser beam as the excitation of light and being modulated to carry an image;

a polygon having reflective facets to rotate around a first rotation axis to scan the laser beam on the screen in a direction perpendicular to the first rotation axis;

a scanning mirror to pivot around a second rotation axis perpendicular to the first rotation axis to scan the laser beam on the screen in a direction parallel to the first rotation axis; and

a beam adjustment mechanism operable to change at least one of a position and a beam pointing of the laser beam along the first rotation axis to control a position of the laser beam on the screen along the first rotation axis.

46. A display device, comprising:

a screen operable to display an image, wherein the screen comprises:

a fluorescent layer comprising a plurality of parallel fluorescent stripes, each fluorescent stripe operable to absorb excitation light to emit light of a designated color; and

a lens layer located on a first side of the fluorescent layer and comprising a plurality of cylindrical lenses which have cylindrical axes parallel to the fluorescent stripes and are positioned to correspond to and to direct light to the fluorescent stripes, respectively.

47. The device as in claim 46, wherein the screen further comprises:

a reflective layer located between the lens layer and the fluorescent layer and configured to have a plurality of slit apertures along the cylindrical axes of the cylindrical lenses, respectively, to transmit light from the lens layer to

the fluorescent layer and to reflect light incident from the fluorescent layer back to the fluorescent layer.

48. The device as in claim 47, wherein the screen further comprises a layer positioned so that the fluorescent layer is located at a position between the fluorescent layer and the reflective layer, the layer operable to reflect the excitation light and to transmit light emitted by the fluorescent layer.

49. The device as in claim 46, wherein the screen further comprises a layer positioned so that the fluorescent layer is located at a position between the fluorescent layer and the lens layer, the layer operable to reflect the excitation light and to transmit light emitted by the fluorescent layer.

50. The device as in claim 46, wherein the screen further comprises a contrast enhancing layer positioned relative to the fluorescent layer so that the fluorescent layer is placed at a position between the contrast enhancing layer and the lens layer,

wherein the contrast enhancing layer comprises a plurality of different filtering stripes that are parallel to and spatially match the fluorescent stripes, wherein each filtering stripe transmits light of a color that is emitted by a corresponding matching fluorescent stripe and blocks light of other colors.

51. The device as in claim 46, wherein the fluorescent layer further comprises: an optical absorbent material mixed in each of the fluorescent stripe and operable to transmit light of a color emitted by the fluorescent stripe and to absorb light of other colors including light of a different color emitted by another fluorescent stripe.

52. The device as in claim 46, wherein the lens layer is made of a material that transmits the excitation light and reflects light emitted by the fluorescent layer.

53. The device as in claim 46, wherein, in the fluorescent layer, at least three adjacent fluorescent stripes are made of three different fluorescent materials: a first fluorescent material to emit light of a first color, a second fluorescent material to emit light of a second color, and a third fluorescent material to emit light of a third color.

54. The device as in claim 46, wherein the screen further comprises a boundary along each side of each fluorescent stripe, the boundary being optically reflective or absorbent.

55. The device as in claim 46, further comprising:

an optical module operable to produce a scanning beam of the excitation light that scans along a direction perpendicular to the parallel fluorescent stripes, the scanning beam carrying optical pulses that carry information on an image to be displayed;

an optical sensing unit positioned to receive a portion of light from the screen and operable to produce a monitor signal indicating a spatial alignment of the scanning beam with respect to different fluorescent stripes on the screen; and

a feedback control mechanism operable to receive the monitor signal and to control the optical module so as to adjust a timing of the optical pulses carried by the scanning beam in response to the monitor signal to correct a spatial alignment error of the scanning beam on the screen indicated by the monitor signal.

56. The device as in claim 55, wherein the optical sensing unit comprises a plurality of optical sensors positioned to receive and detect light from the fluorescent stripes, wherein one optical sensor receives only one of colors emitted by the fluorescent stripes on the screen.

57. The device as in claim 46, further comprising:

a laser module operable to project and scan a laser beam as the excitation light onto the screen, the laser beam carrying optical pulses that carry information on an image to be displayed,

wherein the laser module comprises a modulation control which combines a pulse code modulation and a pulse width modulation to modulate the laser beam to produce image grey scales.

58. The device as in claim 46, further comprising:

a laser module operable to simultaneously project and scan a plurality of laser beams as the excitation light onto different portions of the screen, each laser beam carrying optical pulses that carry information on a portion of an image to be displayed at a respective portion of the screen.

59. The device as in claim 58, wherein the laser module comprises an array of lasers that produce the plurality of laser beams, respectively.

60. The device as in claim 59, wherein the laser module further comprises:

a scanning mirror operable to scan each of the plurality of laser beams on the screen along a direction parallel to the fluorescent stripes; and

a polygon mirror operable to scan each of the plurality of laser beams on the screen along a direction perpendicular to the fluorescent stripe.

61. The device as in claim 60, wherein the laser module further comprises a plurality of laser actuators that are engaged to the lasers, respectively, each laser actuator operable to adjust an orientation of a correspondingly engaged laser to control a position of the corresponding laser beam produced by the laser along a direction that is parallel to the fluorescent stripes on the screen.

62. The device as in claim 59, wherein each laser is operable to produce, in a corresponding laser beam, a single laser mode along a direction perpendicular to the fluorescent stripes and two or more laser modes along a direction parallel to the fluorescent stripes.

63. The device as in claim 46, further comprising a laser module which comprises:

a diode laser operable to produce a laser beam as the excitation light onto the screen, the laser beam carrying optical pulses that carry information on an image to be displayed;

a scanning module to scan the laser onto the screen to display the image;

a mechanism to monitor image data bits to be modulated on the laser beam to produce a black pixel monitor signal; and

a laser control coupled to receive the black pixel monitor signal and operable to operate the diode laser at a driving current below a laser threshold current without turning off the driving current to produce a virtue black color on the screen when the black pixel monitor signal indicates a length of black pixels is less than a threshold

and turn off the driving current to produce a true black color on the screen when the black pixel monitor signal indicates a length of black pixels is greater than a threshold.

64. The device as in claim 46, further comprising:

a laser to produce a laser beam as the excitation of light and being modulated to carry an image;

a polygon having reflective facets to rotate around a first rotation axis to scan the laser beam on the screen in a direction perpendicular to the first rotation axis;

a scanning mirror to pivot around a second rotation axis perpendicular to the first rotation axis to scan the laser beam on the screen in a direction parallel to the first rotation axis; and

a beam adjustment mechanism operable to change at least one of a position and a beam pointing of the laser beam along the first rotation axis to control a position of the laser beam on the screen along the first rotation axis.

65. The device as in claim 46, wherein the screen further comprises:

a reflective layer located between the lens layer and the fluorescent layer and configured to have a plurality of slit apertures along the cylindrical axes of the cylindrical lenses, respectively, to transmit light from the lens layer to the fluorescent layer and to reflect light incident from the fluorescent layer back to the fluorescent layer; and

a layer positioned so that the fluorescent layer is located at a position between the fluorescent layer and the reflective layer, the layer operable to reflect the excitation light and to transmit light emitted by the fluorescent layer.

66. The device as in claim 46, wherein the fluorescent layer further comprising parallel non-fluorescent stripes that

diffuse light incident from one side of the screen to produce diffused light on the other side of the screen, each non-fluorescent stripe is positioned next to a fluorescent stripe.

67. The device as in claim 66, wherein each non-fluorescent stripe comprises a light diffusing material that produces a spatial distribution profile of the diffused light on the other side of the screen is similar to a spatial distribution profile of emitted light by a fluorescent stripe.

68. A display device, comprising:

first, second, and third display modules operable to produce first, second and third monochromatic image components of a final image in first, second, and third different colors, respectively, and to project the first, second and third monochromatic image components on a display screen to produce the final image,

wherein the first display module comprises: (1) a first screen comprising a first fluorescent material to absorb light at an excitation wavelength to emit light at a first wavelength different from the excitation wavelength; (2) a first optical module operable to project and scan at least one optical beam at the excitation wavelength onto the first screen to convert an image in the first color carried by the laser beam into the first monochromatic image component produced by the first fluorescent material on the first screen; and (3) a first projection optical unit operable to project the first monochromatic image component from the first screen to the display screen, and

wherein the first screen further comprises a first layer on a first side of the fluorescent layer operable to transmit light at the excitation wavelength and to reflect visible light including light of the first, second, and third colors.

69. The device as in claim 68, wherein the third laser display module comprises: (1) a third screen which does not have a fluorescent material; (2) a third laser module operable to project and scan at least one optical beam of the third color onto the third screen to directly produce the third monochromatic image component on the third screen; and (3) a third projection optical unit operable to project the third monochromatic image component from the third screen to the display screen.

70. The device as in claim 68, wherein the third display module directly projects and scans at least one optical beam of the third color onto the display screen to directly produce the third monochromatic image component on the display screen.

71. A display device, comprising:

a screen comprising a substrate which has a plurality of different regions, wherein at least a first portion of the different regions comprise at least one fluorescent material that is operable to absorb light at an excitation wavelength to emit fluorescent light at an emission wavelength longer than the excitation wavelength, and wherein at least a second portion of the different regions that are spatially interleaved with the first portion of the different regions do not include a fluorescent material; and

an optical module operable to project and scan an excitation optical beam at the excitation wavelength onto the screen that carries images via an optical modulation to produce images at the first portion of the different regions via the emitted fluorescent light and images at the second portion of the different regions via the scanning excitation optical beam.

72. The device as in claim 71, wherein the optical module is further operable to produce and scan a second optical beam at a wavelength different from the excitation optical beam to produce images at a selected portion within the second portion of the different regions via the scanning second optical beam.

73. The device as in claim 72, wherein the excitation optical beam is blue light, the fluorescent material emits green light under excitation of the blue laser, and the second optical beam is red light.

74. A display device, comprising:

a display screen comprising a fluorescent layer that is operable to absorb excitation light to emit visible light, wherein the fluorescent layer comprises a plurality of parallel fluorescent stripes, wherein at least three adjacent phosphor stripes are made of three different fluorescent materials: a first fluorescent material operable to absorb the excitation light to emit light of a first color, a second fluorescent material operable to absorb the excitation light to emit light of a second color, and a third fluorescent material operable to absorb the excitation light to emit light of a third color; and

the display screen further comprising dividers formed at boundaries between two adjacent fluorescent stripes to separate different fluorescent stripes and configured to reduce an amount of light emitted by one fluorescent stripe that enters an adjacent fluorescent stripe.

75. The device as in claim 74, wherein the dividers are optically absorbent.

76. The device as in claim 74, wherein the dividers are optically reflective.

77. A display device, comprising a screen which comprises:

a substrate;

a plurality of fluorescent regions formed on the substrate, wherein at least two adjacent fluorescent regions include two different fluorescent materials that absorb excitation light to emit light at two different colors; and

a contrast enhancing layer formed over the fluorescent regions and comprising a plurality different filtering regions that spatially match the fluorescent regions, where each filtering region is operable to transmit light of a color that is emitted by a corresponding matching fluorescent region and to block light of other colors.

78. The device as in claim 77, wherein the fluorescent regions are parallel fluorescent stripes, and

the device further comprising a lens layer located on a first side of the fluorescent layer and comprising a plurality of cylindrical lenses which have cylindrical axes parallel to the fluorescent stripes and are positioned to correspond to and to direct the excitation light to the fluorescent stripes, respectively.

79. A display device, comprising:

a display screen comprising a fluorescent layer that absorbs excitation light to emit visible light, and a first layer on a first side of the fluorescent layer operable to transmit the excitation light and to reflect the visible light, wherein the first layer comprises a composite sheet of a plurality of dielectric layers.

80. The device as in claim 79, further comprising a Fresnel lens formed on the first side of the fluorescent layer

to direct the excitation light incident to the screen at different angles to be approximately normal to the fluorescent layer.

81. The device as in claim 79, wherein the fluorescent layer comprises a plurality of parallel phosphor stripes spaced from one another.

82. The device as in claim 81, wherein the display screen further comprises a lens layer on the first side of the fluorescent layer, the lens layer comprising a plurality of cylindrical lenses having cylindrical axes parallel to the phosphor stripes and being positioned to correspond to the phosphor stripes, respectively.

83. The device as in claim 79, wherein the dielectric layers are polymeric materials.

84. The device as in claim 79, wherein the dielectric layers are polyester materials.

85. The device as in claim 79, wherein the fluorescent layer comprises different fluorescent regions that emit light of different colors, and a boundary of two adjacent different fluorescent regions is either optically reflective or optical absorbent.

86. The device as in claim 79, wherein the screen further comprises a second layer on a second side of the fluorescent layer to transmit visible light and to block the excitation light.

87. The device as in claim 86, wherein the second layer comprises a composite sheet of a plurality of dielectric layers.

88. A display device, comprising:

an optical module operable to produce a scanning beam of excitation light, the scanning beam carrying optical pulses that carry information on an image to be displayed;

a screen comprising at least a first fluorescent material which absorbs the excitation light and emits light of a first color to produce the image carried in the scanning beam;

an optical sensing unit positioned to receive a portion of light from the screen comprising the light of the first color and operable to produce a monitor signal indicating a spatial alignment of the scanning beam on the screen; and

a feedback control mechanism operable to receive the monitor signal and to control the optical module so as to adjust a timing of the optical pulses carried by the scanning beam in response to the monitor signal to correct a spatial alignment error of the scanning beam on the screen indicated by the monitor signal.

89. The device as in claim 88, wherein the screen further comprises first regions at different locations where the first fluorescent material to emit the light of the first color when hit by the scanning beam and second regions at different locations without a fluorescent material where the scanning beam is diffused to display a color of the scanning beam when hit by the scanning beam.

90. The device as in claim 88, wherein the screen further comprises a second fluorescent material which absorbs the excitation light and emits light of a second color and a third fluorescent material which absorbs the excitation light and

emits light of a third color, wherein the first, second and third fluorescent materials are distributed at different locations on the screen.